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PERFORMANCE AND EMISSION ANALYSIS OF PETRO PLAST FUEL IN SI ENGINE

S.SIVAMANIKANDAN[1] , L.SITHARTHAN[2] , A.RAGAVENDRAN[3]

C.VEMBAIYAN, M.E., Asst.Professor, Department of Mechanical Engineering,
MRK Institute Of Technology, Kattumannarkoil, cuddalore district, tamilnadu, india[1]

ABSTRACT*-The process of converting waste plastic into value added fuels is explained as a viable solution for recycling of plastics. The Performance and emission analysis of multi cylinder petrol engine when fueled with petro plast fuel are investigated and compared with standard petrol. Petro plast fuel produced from waste plastics by pyrolysis process has been used. This process runs without oxygen and in high temperature of about 300°C which is why a reactor was fabricated to provide the required temperature for the reaction. Experiment has been conducted at a fixed engine speed of 2500 rpm and various loads of 20%, 40%, 60%, 80%. The impact of load on fuel consumption and exhaust gas emissions has been investigated and presented. The results indicate break thermal efficiency increased when used petro plast fuel. The petro plast fuel when used as fuel results in reduction of NO_x , HC, CO_2 , O_2 and slightly increase in CO emission.*

***Keywords*— waste plastics, pyrolysis, fly ash, petrol engine, performance test.**

1) INTRODUCTION

Plastics are an integral part of our modern life and are used in almost all daily activities. Since plastics are synthesized from non-renewable sources and are generally not biodegradable, waste plastics are the cause of many of the serious environmental problems the world faces today. However, waste plastics can become a source of enormous energy with the correct treatment. In recent years, huge amounts of waste plastic are available in municipal solid waste (MSW) and many places. With an annual increase rate of approx 50%, in 1995, the production of plastic in the world had reached 150 million tons. According to information the yield of waste plastic is 100 million tons. Various type waste plastic use now a days. Established technology can convert waste plastics into a renewable source of hydrocarbon fuel. This technology plans to acquire waste plastics from City / Local Municipalities and Recycling Facilities. For plastic fuel

production purposes the plastics can be collected as commingled or separated into different categories. Another source of large amounts of waste plastic is floating on our oceans and seriously damaging the ecosystem and the environment.

1.1 NEED FOR ALTERNATIVE FUEL

Since gasoline and diesel will become scarce and expensive, alternative fuel will be pursued in the coming decades. Some IC engines fuelled with non-gasoline or diesel oil fuels. However, they are relatively less in proportions. Because of high cost of petroleum products, some developed countries are tried to use alternative fuels for vehicles.

1.2 PLASTIC

Plastic covers a range of synthetic or semi synthetic polymerization products which can be mould into any desired shape when subjected to heat and pressure. They composed of organic condensation or addition polymers and may contain other substances to improve performance or economics. A finished high-polymer article not only consists solely of high polymeric material (polymer or resin) but is mixed with 4 to 6 ingredients, such as lubricant, filler, plasticizer, stabilizer, catalysts, and colouring material.

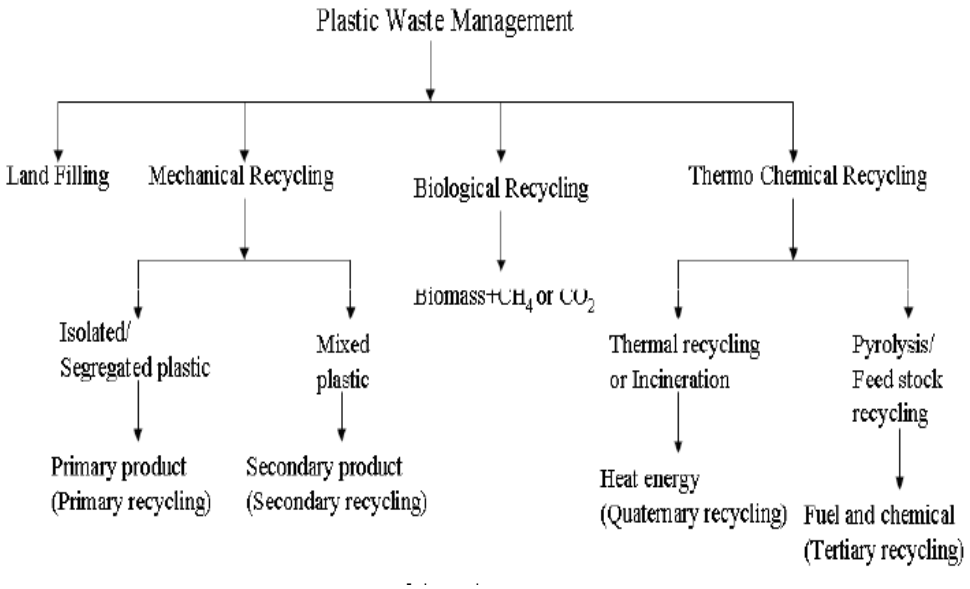
There are mainly two types of Plastics: Thermoplastics and Thermosetting Plastics.

2 WASTE PLASTIC MANAGEMENT

Plastic Waste Management has assumed great significance in view of the urbanization activities. Various strategies are being devised to mitigate the impact of plastic waste in India Some significant challenges still exist from both technological factors and from economic or social behavior issues relating to the collection of recyclable wastes, and substitution for virgin material.

Waste management is all those activities and action required to manage waste from its inception to its final disposal. This includes amongst other things, collection, transport, treatment and disposal of waste together with monitoring and regulation. It also encompasses the legal and regulatory framework that relates to waste management encompassing guidance on recycling etc.

The term usually relates to all kinds of waste, whether generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, or other human activities, including municipal (residential, institutional, commercial), agricultural, and special (health care, household hazardous wastes, sewage sludge). Waste management is intended to reduce adverse effects of waste on health, the environment or aesthetics.



3.1 TYPES OF WASTE PLASTIC MANAGEMENT

They are different types waste plastic management present in the world as follows

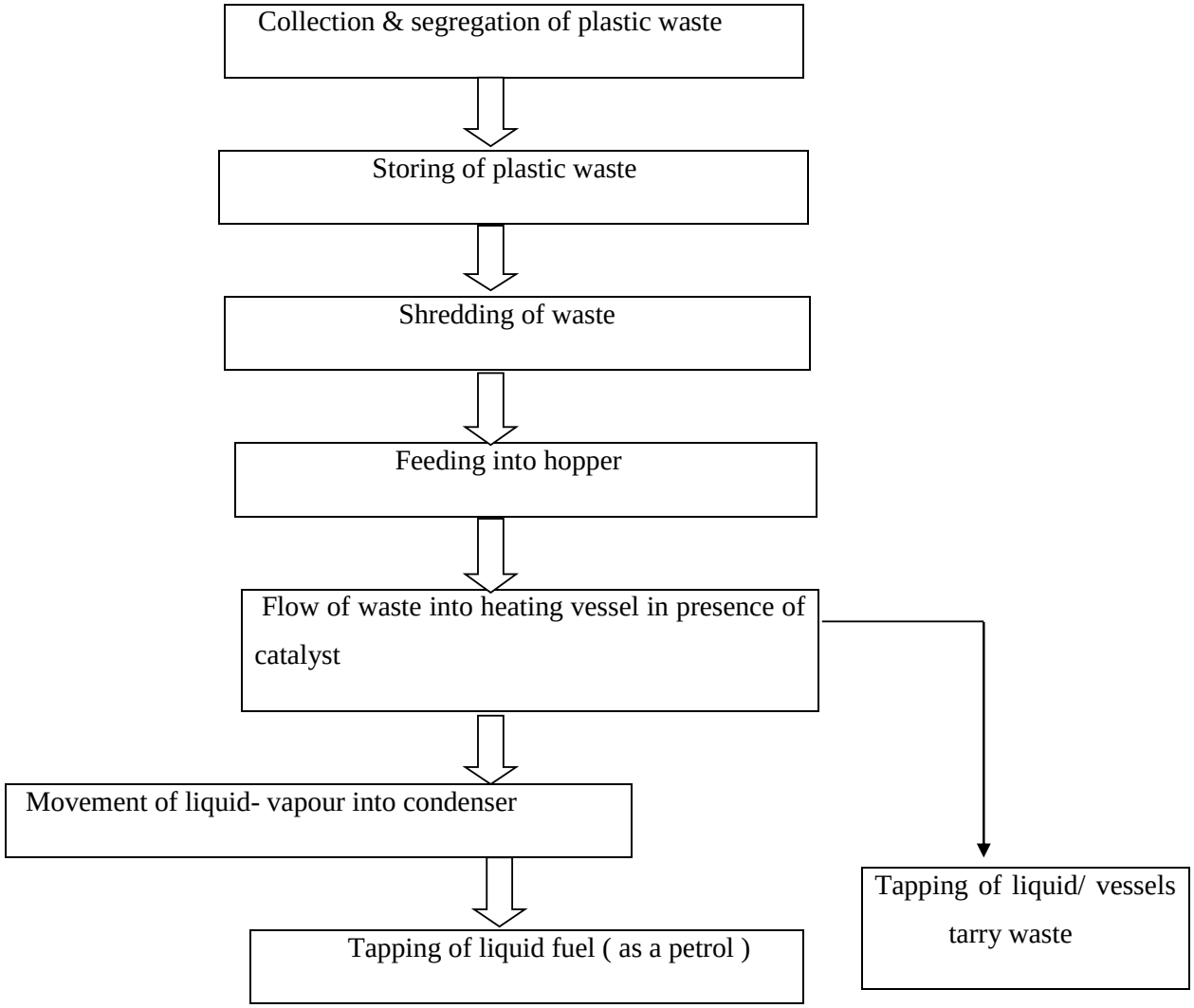
1. Landfill
2. Recycling
3. Biological reprocessing
4. Incineration
5. pyrolysis

3.2 OBJECTIVE OF THE WORK

These project works consists of two stages experimental investigations. The first phase the waste plastic oil preparation and performances analysis of plastic fuel for Petrol Engine. The

second phase of the investigation petrol engine operated on petrol fuel and waste plastic oil and also reduces the exhaust gas amount from Engine Emission.

4 Methodologies



5 TYPES OF CATALYST

They are many type of catalyst used in pyrolysis process as follows

1) Fly ash
2) Silica alumina

3) Zeolites
4) Usy
5) Zsm-5
6) Rey
7) Clinoptilolite
8) MCM-41.

Among these processes of Pyrolysis is the most commonly used catalyst is fly ash the reason are economically cheep and better efficiency.

5.1 FLY ASH

Fly ash, also known as "pulverised fuel ash" in the United Kingdom, is one of the Coal combustion products, and is composed of the fine particles that are driven out of the boiler with the flue gases. the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminium oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata.

6. PYROLYSIS PROCESS

Pyro = heat. Lysis = break down. Plastic Pyrolysis is chemical reaction. This reaction involves molecular breakdown of larger molecules into smaller molecules in presence of heat. Pyrolysis is also known as thermal cracking, cracking, thermolysis, depolymerization, etc.

Pyrolysis technology is thermal degradation process in the absence of oxygen. Plastic waste is treated in a cylindrical reactor at temperature of 300ºC – 350ºC. The plastic waste is gently cracked by adding atalyst and the gases are condensed in a series of condensers to give a low sulphur content distillate.

All this happens continuously to convert the waste plastics into fuel that can be used for generators. The catalyst used in this system will prevent formation of all the dioxins and Furans (Benzene ring). All the gases from this process are treated before it is let out in atmosphere. The flue gas is treated through scrubbers and water/ chemical treatment for neutralization. The non-condensable gas goes through water before it is used for burning. Since the Plastics waste is processed about 300ºC - 350ºC and there is no oxygen in the processing reactor, most of the toxics are burnt. However, the gas can be used in dual fuel diesel-generator set for generation of electricity.

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Pyrolysis Equipment

produce pyrolysis oil

Conversion Of Plastics Waste Into Liquid Fuel

7. DISTILLATION PROCESS

This process applied for petrol and diesel grade fuel production process. Waste plastic to fuel was use for further distillation process and making petrol and diesel grade fuel. Distillation column was use for distillation process. Distillation process set up different columns with different temperature profile like low boiling point fuel to high boiling point fuel. Petrol grade fuel collected from 1st fractional column and temperature range was 90°C to 130°C. Diesel grade fuel collected from 2nd fractional column and temperature range was 250°C to 285°C. In distillation process, 2nd grade fuel was diesel fuel and diesel fuel density 0.80 g/ml. This fuel hydrocarbon compound also heavier and this fuel are not igniting. Collected diesel grade fuel percentage was 29% and rest of all other fractional fuel percentage was 71% including light gas also. Fractional distillation process was also generating some light gases. Light gas cleaning procedure also same above procedure. Plastic pyrolysis fuel to different fuel by using fractional distillation column used for heat applied with different column temperature wise and fuel break down into shorter into longer chain wise and come out into different fraction column then collected into different separate container for grade wise.

Petrol And Waste Petro plast fuel

8. PROPERTIES OF PETROL AND PETRO PLAST FUEL

S.NO	Property	petrol	Waste plastic fuel

1	Density at 15°C kgm/cc	830	**795.5**
2	Viscosity at 40°C mm^2/sec	4.59	**4.62**
3	Flash Point ^{O}C	22	**23**
4	Fire Point ^{O}C	25	**26**
5	Cloud Point ^{O}C	2	**1**
6	Pour Point	-4	**-4.5**
7	Calorific value	44800	**41800**

9. EXPERIMENTAL SETUP

The experimental setup consists of multi cylinder petrol engine. Engine exhaust is connected to inlet of five gas analyzer. Eddy current dynamometer is used to provide necessary load, which is manually controlled by the engine control panel.

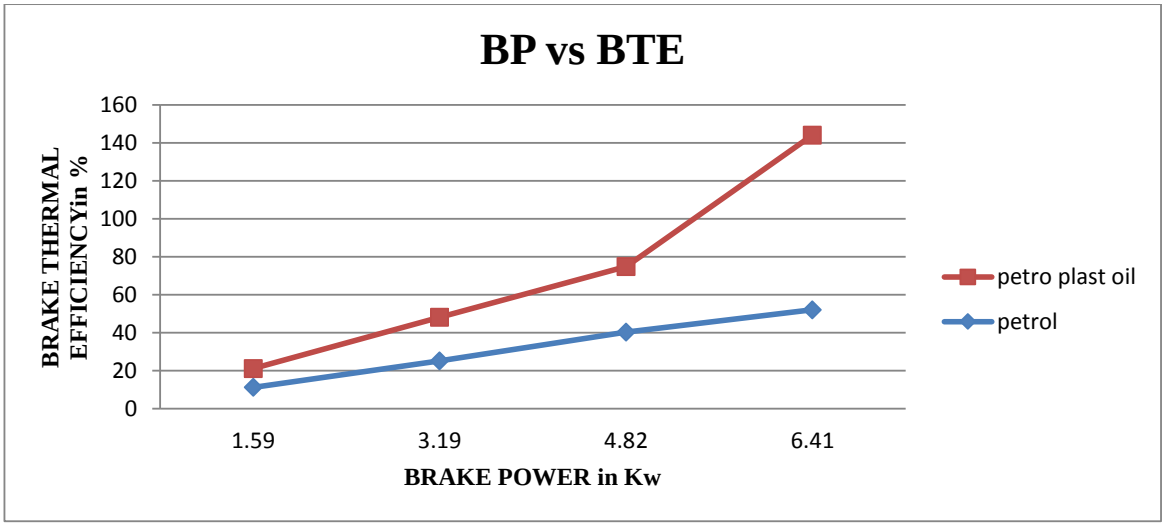
The setup enables study of engine performance for brake power, BMEP, brake thermal efficiency, and specific fuel consumption. Lab view based Engine.

9.1 PERFORMANCE ANALYSIS OF S.I. ENGINES

1. **BRAKE THERMAL EFFICIENCY (η_{bth})**

A measure of overall efficiency of the engine is given by the brake thermal efficiency. Brake thermal efficiency is the ratio of energy in the brake power to the fuel energy.

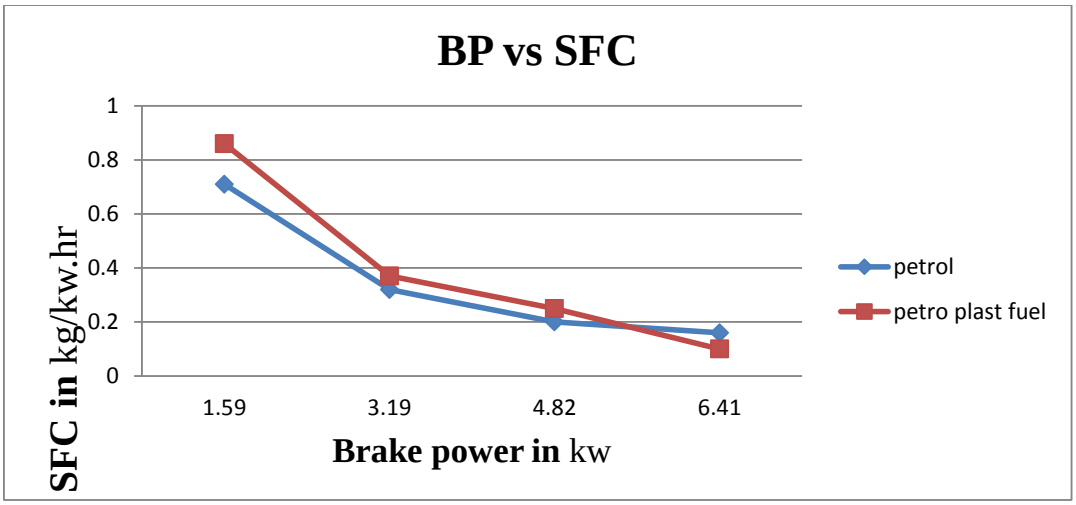
x 100



comparison of BTE with petrol and petro plast fuel

2. SPECIFIC FUEL CONSUMPTION (SFC)

BSFC and ISFC, are the fuel consumption son the basis of Brake power and Indicated power respectively.



Comparison of SFC with petrol and petro plast fuel

3. FUEL-AIR (F/A) OR AIR-FUEL (A/F) RATIO

The relative proportions of the fuel and air in the engine are very important from standpoint of combustion and efficiency of the engine. This is expressed either as the ratio of the mass of the fuel to that of the air or vice versa. Calorific value or Heating value or Heat

of combustion: It is the energy released per unit quantity of the fuel, when the combustible is burned and the products of combustion are cooled back to the initial temperature of combustible mixture. The heating value so obtained is called the higher or gross calorific value of the fuel. The lower or net calorific value is the heat released when water in the products of combustion is not condensed and remains in the vapor form.

4. BRAKE POWER

Brake power is defined as rate of doing work and equal to the product of force and linear velocity or the product of torque and angular velocity. Thus, the measurement of power involves the measurement of force (or torque) as well as speed.

The power developed by an engine at the output shaft is called brake power and is given by

Where,

W = Load in kg

N = speed in RPM

C = Dynamic Constant (9549.3)

10. FORMULAS

1. **BRAKE POWER** (Kw)

Where,

W = Load in Kg

N = speed in Rpm

C = Dynamic Constant (9549.3)

2. **FUEL POWER**

Where,

CV = Calorific Value of Fuel in Kj/Kg

3. **SPECIFIC FUEL CONSUMPTION** (Kg/Kwh)

4. **Brake Thermal Efficiency (%)**

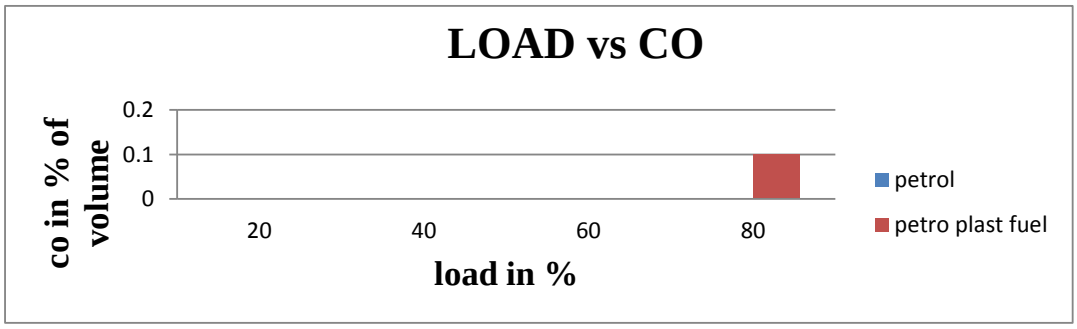
Brake thermal Efficiency =

10. EMISSION PARAMETER

Petrol Engine emission have been major contributor to air pollution regulated pollutants are carbon monoxide, NOx and unburned fuel or partly oxidized HC. which are summarized as follows.

10.1 CARBON MONOXIDE EMISSION (CO)

The CO emission was found to be lower than that of petrol for alternative fuel and its blend at full load condition. CO is formed due to incomplete combustion of fuel due to lack of oxygen or lower engine speed. If burning of fuel is complete, carbon monoxide will be transformed to CO_2. However at higher compression ratio the carbon monoxide percentage starts increasing progressively owing to higher combustion chamber temperature, fuel/air ratio, deficiency of oxygen at high speed and reduction in the available time for complete combustion.

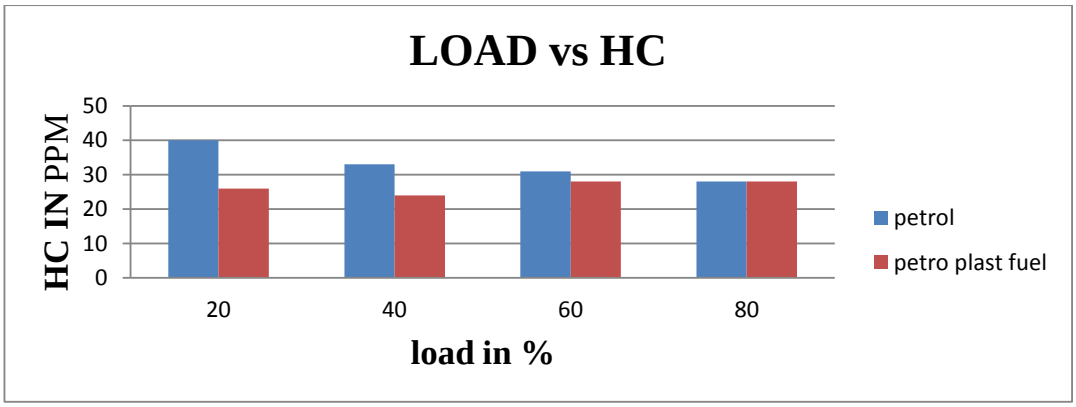


Comparison of CO emission with use of petrol and petro plast fuel.

10.2 HYDROCARBON EMISSION (HC)

In completely combustion is solely responsible for the emission of unburned HC the effect of CR on unburned HC emission. From the figure it can be seen that higher compression ratios show lesser emissions. Hydrocarbon emissions were found to be lesser for alternative fuel blends that of petrol. With an increase in alternative fuel proportions in the petrol there was a

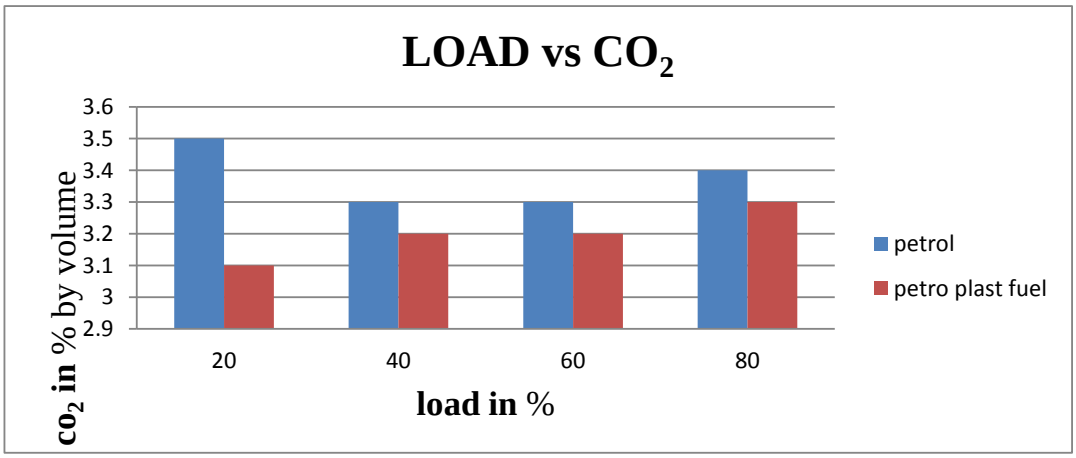
further reduction in HC emissions. The inherent atoms of oxygen in the alternative fuel may well be responsible for this reduction.



Comparison Of HC Emission With Use Of petrol And petro plast Fuel

10.3 CARBON DIOXIDE EMISSION (CO_2)

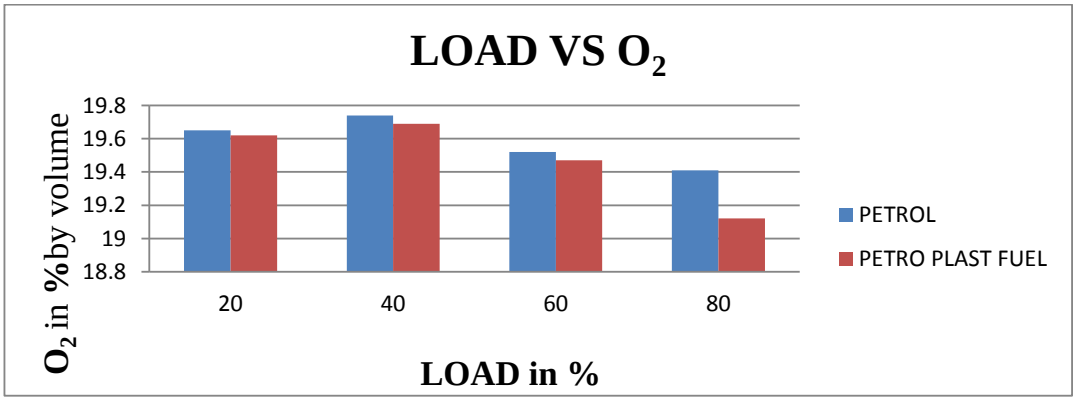
The CO_2 emission was found to be lower than that of petrol for alternative fuel and its blend at full load condition. CO_2 is formed due to incomplete combustion of fuel due to lack of oxygen or lower engine speed. If burning of fuel is complete, carbon monoxide will be transformed to CO_2. However at higher compression ratio the carbon monoxide percentage starts increasing progressively owing to higher combustion chamber temperature, fuel/air ratio, deficiency of oxygen at high speed and reduction in the available time for complete combustion.



Comparison Of CO_2 Emissions With Use Of petrol and petro plast fuel

10.4 OXYGEN EMISSION (O2)

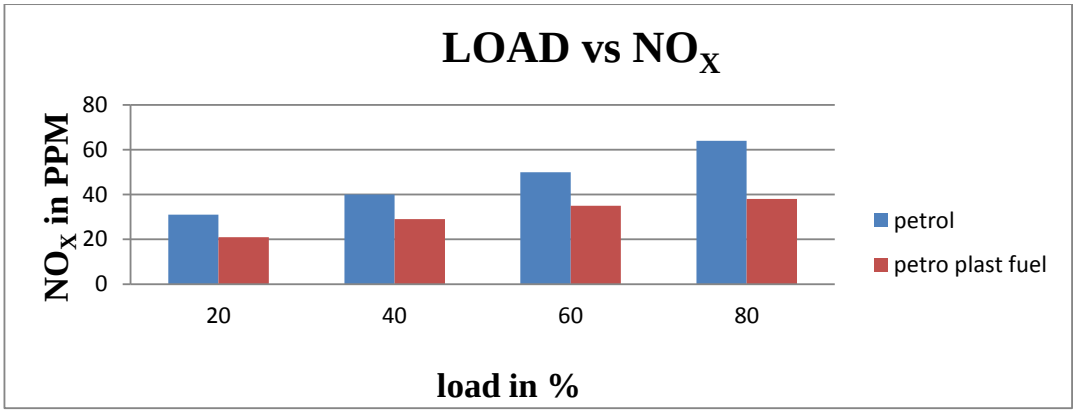
Oxygen concentration of the exhaust in percent of the total sample. Free O2 occurs in the exhaust when there is an excess of air in the mixture. The O2 contain increase sharply as soon as lambda rises above 1. Taken with the CO2maximum, the oxygen content is a clear indicator of the transition from rich to lean mixture range, or leaks in the manifold or exhaust systems or combustion failures. With rich mixture most of the oxygen is burned during combustion. Whit very lean mixture more O2 escapes "un-combusted" so the level rises.



Comparison Of O_2 With Use Of petrol And petro plast fuel

10.5 OXIDES OF NITROGEN EMISSION (NOX)

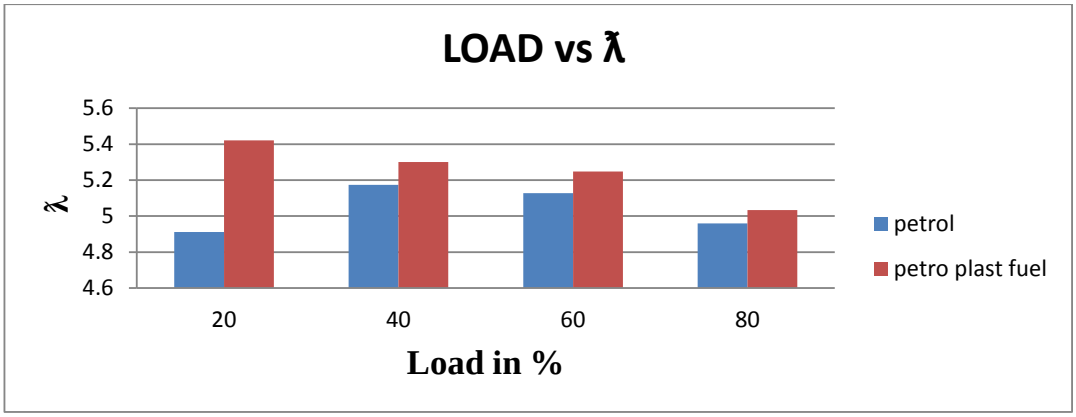
The most serious emissions from petrol engines are oxides of nitrogen. The creation of NOx is extremely reliant on the in cylinder temperature, concentration of oxygen and dwelling general as the compression ratio increases the NOx emission is also increased as the operating temperature is high. It was evident that the NOx emission or petrol is higher than that of alternative fuel and its blend. This may be due to the presence of in built oxygen atom in the molecular structure of alternative fuel.



Comparison of NO_X With Use Of petrol And petro plast fuel

10.6 LAMBDA OR A/F RATIO FOR EXHAUST

Air/Fuel Ratio or Lambda value based on the HC, CO, CO2 and O2 concentrations. Remember the ideal (Stoichiometric) A/F is 14.7 liters air to 1 liter fuel or 14.7/1. The ideal Lambda value is 1(one) below that the A/F mixture is rich and above - lean. For example, lambda=0.8 corresponds to an air/fuel ratio of (0.8x14.7):1=11.76:1 (e.g. lambda 0.8 = A/F ratio of 11.76/1 or very rich air fuel mixture)



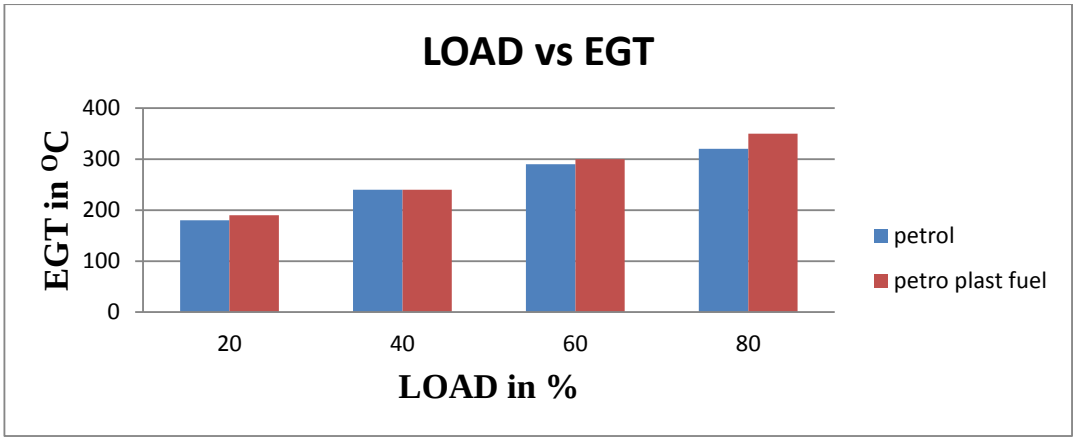
Comparison of lambda with use of petrol and petro plast fuel

10.7 SMOKE

Smoke formation happens at extreme shortage of air locally pre availing inside the engine cylinder. It increases as the air to fuel ratio decreases. The emission of smoke at full load condition by varying the compression ratio of the engine for petrol as well as alternative fuel blends. Smoke emissions at full load vary inversely with compression ratios, since at higher CR the working pressure and temperature increases and hence forth there is an increase in combustion efficiency. The smoke opacity for alternative fuel and its blend were found to be lower than that of petrol at all the compression ratios. There is a significant reduction in the smoke opacity with increase in alternative fuel concentration. The extra quantity of oxygen atom in the alternative fuel could be responsible for reduced smoke emissions.

10.8 EXHAUST GAS TEMPRATURE

Exhaust gas temperature (EGT) is important to the functioning of the catalytic converter of a petrol engine. It may be measured by an exhaust gas temperature gauge. EGT is also a measure of engine health in gas-turbine engine.



Comparison of EGT with use of petrol and petro plast fuel

11. PERFORMANCE AND EMISSION TEST

FUEL: PETROL

SPEED =2500 RPM BP =8KW CV=44800

Load in %	Calculated load	TIME TAKEN FOR MINUTE OF FUEL CONSUMPTION			PERFORMANCE ANALYSIS			EMISSION ANALYSIS						
	N	F1 INITIAL	F2 FINAL	F1-F2	BRAKE POWER (BP)	SPECIFIC FUEL CONSUMPTION (SFC)	BRAKE THERMAL EFFICIENCY	CO	HC	CO_2	O_2	NO_X	λ	EGT
					(kw)	(kg/kw.hr)	%	% BY VOLUME	PPM	% BY VOLUME	% BY VOLUME	PPM		°C
20	6.1	1.453	1.434	0.019	1.596	0.714	11.2	0	40	3.50	19.65	31	4.91	180
40	12.2	1.428	1.411	0.017	3.193	0.319	25.16	0	33	3.30	19.74	40	5.17	240
60	18.4	1.404	1.388	0.016	4.817	0.197	40.34	0	31	3.30	19.52	50	5.12	290
80	24.5	1.380	1.365	0.015	6.414	0.159	52	0	28	3.40	19.41	64	4.95	320

Performance and Emission Test for Petrol

FUEL= PETRO PLAST

SPEED =2500 RPM BP =8KW CV=41800

Load in %	Calculated load	TIME TAKEN FOR MINUTE OF FUEL CONSUMPTION			PERFORMANCE ANALYSIS			EMISSION ANALYSIS						
	N	F1 INITIAL	F2 FINAL	F1-F2	BRAKE POWER (BP)	SPECIFIC FUEL CONSUMPTION (SFC)	BRAKE THERMAL EFFICIENCY	CO	HC	CO_2	O_2	NO_X	λ	EGT
					(kw)	(kg/kw.hr)	%	% BY VOLUME	PPM	% BY VOLUME	% BY VOLUME	PPM		°C
20	6.1	1.359	1.336	0.023	1.596	0.864	9.96	0	26	3.10	19.62	21	5.42	190
40	12.2	1.331	1.311	0.020	3.193	0.375	22.92	0	24	3.20	19.69	29	5.30	240
60	18.4	1.304	1.284	0.020	4.817	0.249	34.58	0	28	3.20	19.47	35	5.24	300
80	24.5	1.280	1.266	0.014	6.414	0.093	65.74	0.01	28	3.30	19.12	38	5.03	350

Performance and Emission Test for Petro Plast Fuel

12. RESULT AND DISCUSSION

A petroleum based fuel has been produced from waste plastic by using a pyrolysis process and adding a catalyst for fly ash. By heating the close combustion chamber with

temperature range of 170 -350 ^{o}c then 2kg of waste plastic and 100gms of fly ash added to without oxygen of a combustion chamber and we get approx 1lit fuel oil after 3hour.

By using 500ml of this fuel in Multi cylinder four stroke petrol engine by considering various parameters. The tests were conduct for this petro plast fuel and petrol for conventional engine. The tests will conduct from 20% load to 80% load conditions. The readings such as time taken to consume 10cc of specific fuel consumption and standard speed of 2500 rpm.

Hydro Carbon, Carbon monoxide, carbon dioxide, oxygen, NO_x, lambda, EGT were noted from an ALV five gas analyzer. The observations were recorded in tabular column and calculations will make using appropriate equations.

It is concluded that the petro plast fuel represents a good alternative fuel for SI engine.

13. CONCLUSION

Based on the reviewed paper for the performance and emissions of petro plast fuel, it is concluded that the petro plast fuel represents a good alternative fuel for petrol and therefore must be taken into consideration in the future for transport purpose.

Further it is concluded that

1) Engine was able to run with 100% petro plast fuel and without any modification of engine.
2) Brake thermal efficiency of the engine fueled with petro plast fuel with retarded injection timing is found to be higher.
3) At the 80% load the BSFC is higher petro plast fuel show the SFC higher than the petrol.
4) The exhaust gas temperature for petro plast fuel is higher than petrol at a 20% load to 80% load condition.
5) The air fuel ratio for petro plast fuel is higher than petrol at a 20% load to 80% load condition.
6) The emission gases like CO_2 , HC, O_2 ,NO_x for petro plast fuel is reduce than petrol and slightly increase of CO at a 80% load condition.

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